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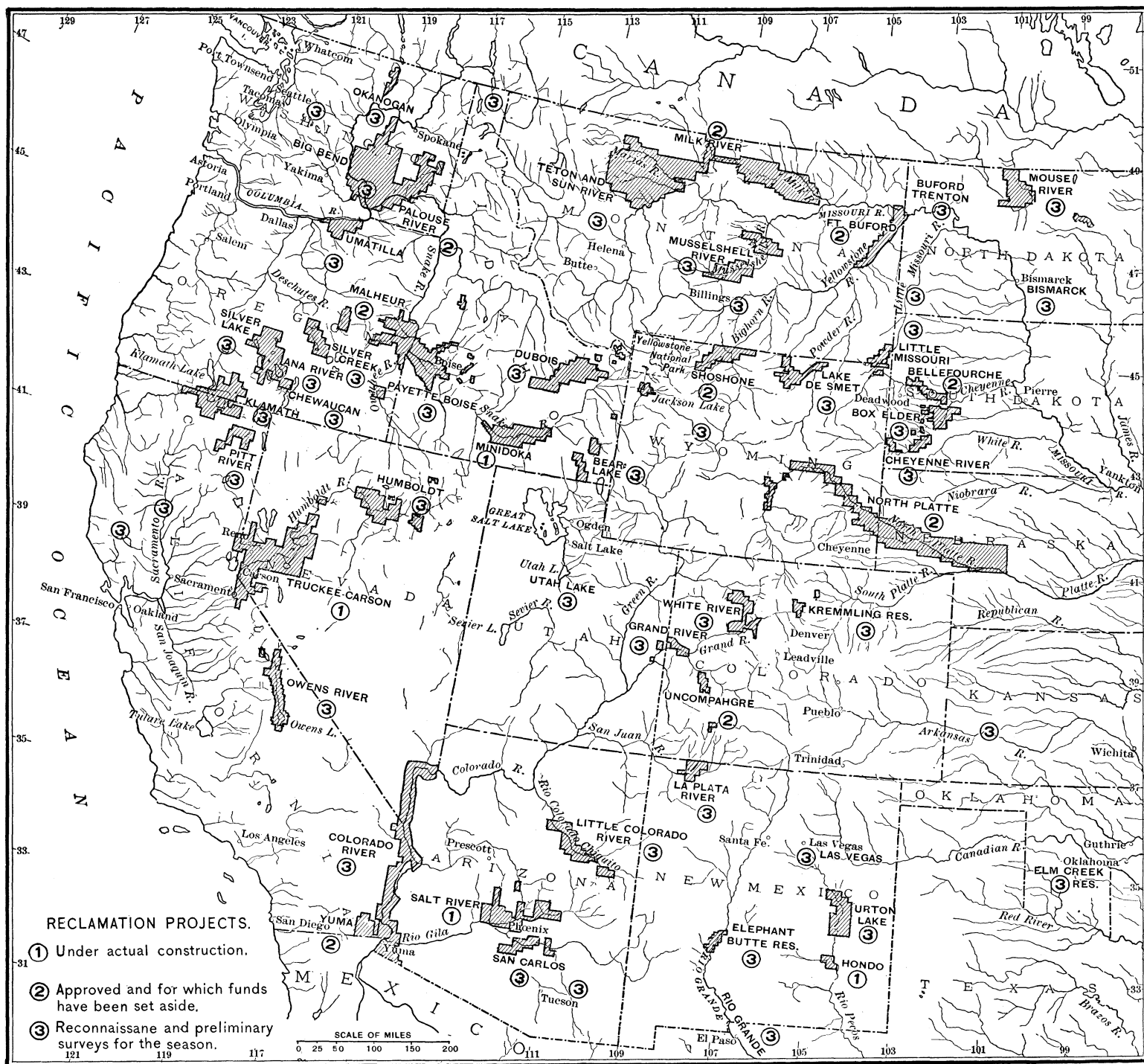
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No. 1

THE UNITED STATES RECLAMATION SERVICE.

BY

C. J. BLANCHARD.

The third field season of the U. S. Reclamation Service since its organization on June 17, 1902, is closed, except in the Southwest, where climatic conditions do not prevent continuance of field work throughout the year.

A summary of the reports of the district engineers for the thirteen States and three Territories in the arid region furnishes most convincing evidence that the Reclamation Service has been organized on broad and thoroughly practical lines, which are calculated to insure the largest measure of results with the most economical expenditure of the reclamation fund.

Since the inception of the Service the general conduct of the work has been under the charge of Mr. Frederick H. Newell, as head of the Hydrographic Branch of the Geological Survey and Chief Engineer of the Reclamation Service. He has from time to time added to his advisory board consulting engineers and specialists of experience and ability, the general staff now including the following:

Arthur P. Davis, Assistant Chief Engineer; J. B. Lippincott, H. N. Savage, J. H. Quinton, and C. H. Fitch, supervising engineers; G. Y. Wisner, B. M. Hall, W. H. Sanders, A. J. Wiley, and C. S. Schlichter, consulting engineers; Morris Bien, engineer-in-charge of investigations of land titles; N. H. Darton, hydrographer-in-charge of the western section of hydrology; H. A. Storrs and O. H. Ensign, electrical engineers; G. A. Hammond, superintendent of borings; T. H. Means, engineer of soils; and others.

The proceeds from the sales of public lands in the thirteen

States and three Territories constitute what is known as the reclamation fund. The following table gives by States the total amount of funds received from the sale of public lands during the fiscal years 1901-04. For 1904 the figures are approximate only, but the totals are sufficiently exact for the purpose of estimates:

TABLE I.

STATE OR TERRITORY.	1901.	1902.	1903.	(APPROXIMATE) 1904.	AGGREGATE.
Arizona.....	\$42,586.16	\$39,187.35	\$48,360.20	\$36,270.15	\$166,403.86
California.....	205,030.40	298,240.36	839,221.40	629,416.05	1,971,908.21
Colorado.....	254,889.88	374,105.13	549,812.89	412,359.66	1,591,167.56
Idaho.....	206,645.36	300,803.27	650,331.95	487,748.97	1,645,529.55
Kansas.....	20,188.78	28,946.94	27,836.50	20,877.36	97,849.58
Montana.....	367,342.31	405,035.49	558,071.49	418,553.61	1,749,002.90
Nebraska.....	102,963.24	132,234.94	138,728.70	104,046.54	477,973.42
Nevada.....	9,183.47	14,230.61	14,136.76	10,602.57	48,153.41
New Mexico.....	75,203.06	72,034.60	154,265.49	118,629.11	420,202.26
North Dakota.....	449,474.96	778,021.35	1,244,916.47	933,687.36	3,406,100.14
Oklahoma.....	370,464.93	638,330.44	864,766.83	678,575.13	2,552,137.33
Oregon.....	364,988.62	543,972.44	1,896,970.68	1,422,728.01	4,230,659.75
South Dakota.....	113,274.20	194,288.17	248,696.14	186,522.09	742,780.60
Utah.....	98,416.00	48,408.38	88,872.38	66,654.27	302,351.03
Washington.....	257,180.95	536,907.82	1,109,299.54	831,974.67	2,735,362.98
Wyoming.....	206,989.59	178,773.24	279,709.18	209,781.87	875,253.88
Total.....	\$3,144,821.91	\$4,585,520.53	\$8,713,996.60	\$6,568,497.42	\$23,012,836.46

Examination of the above table shows that the largest contributions to the fund have been received from Oregon, North Dakota, Washington, Oklahoma, and California. In the Pacific Coast States along the Coast Range are the most valuable timber-lands on our continent, and from this source has come the principal revenue of the land offices in those States. North Dakota and Oklahoma, one almost wholly in the humid and the other partly in the semi-arid belt, have enjoyed a land boom, and thousands of settlers have taken up Government land.

The receipts from public land sales show a falling off in 1904, and it is probable that the fund reached its maximum in 1903, and in succeeding years will gradually diminish. This is to be expected, for the reason that the cultivable areas have largely passed to private ownership. Vast areas of timber-lands have been included in forest reserves, thus eliminating these as sources of future income. The unoccupied areas, for the most part, consist of rough mountain slopes, high bench lands, and valleys deficient in rainfall or running streams. Until expensive irrigation works are constructed these valleys will continue as part of the public domain.

LAYING OUT THE WORK OF RECLAMATION.

In each of the arid States and Territories a district engineer has been placed in charge of the work of investigating irrigation possi-

bilities, directing the operations of numerous field parties, and preparing preliminary plans for submission to consulting boards appointed by the Chief Engineer. The following is a list of the district engineers:

L. C. Hill, Arizona; Homer Hamlin, California; A. L. Fellows, Colorado; D. W. Ross, Idaho; C. C. Babb, Montana; J. E. Field, Nebraska; L. H. Taylor, Nevada; F. E. Weymouth, North Dakota; W. M. Reed, New Mexico; G. H. Matthes, Oklahoma; J. T. Whistler, Oregon; R. F. Walter, South Dakota; G. L. Swendsen, Utah; T. A. Noble, Washington; and J. Ahern, Wyoming. Each of these engineers is made a member of the board of consulting engineers at all meetings held for the purpose of considering projects in his State.

When it is considered that the field covered by the district engineers and their assistants includes an area equal to two-fifths of the United States; that the regions investigated are generally far removed from settlements, embracing vast areas of sage brush, desert and rough mountain country, the progress of the bureau has been rapid. The results have been of such value that actual construction has been carried on for nearly a year on projects in Arizona and Nevada.

A better conception of the scope of the work may be had by examining the map herewith, which shows: 1st, the projects upon which work has been begun; 2nd, projects which have been approved by the Secretary of the Interior; 3rd, the locations of reconnaissance surveys during the year.

The following table shows by States and Territories the projects which have been approved by the Reclamation Service, and the amounts set aside from the reclamation fund for construction:

PRINCIPAL RECLAMATION PROJECTS.

Arizona	Salt River	\$3,000,000
California	Yuma	3,000,000
Colorado	Gunnison	2,500,000
Idaho	Minidoka	2,600,000
Montana	Milk River	1,500,000
Nebraska (Wyo.)...	Pathfinder	1,000,000
Nevada	Truckee	3,000,000
New Mexico	Hondo	275,000
North Dakota	Fort Buford	1,200,000
Bismarck	Pumping project	250,000
Buford-Treaton...	" " 	300,000
Forward		<u>\$18,625,000</u>

Brought forward.	\$18,625,000
Oregon Malheur	2,000,000
South Dakota..... Belle Fourche	2,100,000
Utah Utah Lake.....	1,000,000
Washington Palouse.....	1,500,000
Wyoming..... Cody	2,250,000
Total.....	<u>\$27,475,000</u>

WORKS UNDER CONSTRUCTION.

Actual construction was begun in April, 1904, on the Salt River project in Arizona. This is a work of extraordinary interest to the Service, by reason of the peculiar and difficult engineering features involved. Sixty miles above Phoenix, and immediately below the mouth of Tonto Creek, the Salt River flows through a deep and narrow rock-walled gorge. The engineers propose to lock these walls together with a dam 210 feet high, 180 feet wide on the bottom, and 700 feet long on top, constructed of masonry as firm and as enduring as the hills from which it will be hewn. This lofty dam will hold in check the flood and normal discharge of Salt River, creating a lake 25 miles or more in length, and conserving 1,200,000 acre-feet of water. The stored waters will be turned into the river channel, to be caught up again by canals in the vicinity of Phoenix and turned upon from 160,000 to 200,000 acres of land.

In the construction of the dam, which is to be one of the most remarkable structures of its kind in the country, more than 200,000 barrels of cement will be required. Owing to the inaccessible locality of the dam site, it was found that the cost of cement delivered at that point was prohibitive. Excellent materials for the manufacture of a high quality of cement were found in the vicinity, and authority was asked and granted for the erection of a mill above the site proposed for the dam. A contract has been awarded for the work to be completed by the first of January. It is expected that the contractors who are excavating the power canal will complete their work by the first of May, 1905.

At the dam site, and at other points along the river where favourable sites exist, power will be developed and utilized for pumping, power being transmitted to sub-stations, and from these distributed at a lower voltage to pumping stations in the valley. Special interest attaches to the power development of this project from the fact that it may be partly utilized for the reclamation of large areas belonging to the Pima, Papago, and Maricopa Indians, whose distress and suffering, by reason of the deficient

water supply on their reservation, have been made the subject of numerous appeals to Congress for relief. The Indian lands apparently are underlain by good water-bearing strata at moderate depths; and with cheap power, developed on the Salt and Gila Rivers, it is believed that several thousand acres can be reclaimed and rendered productive by the Indians. The estimated cost of the Roosevelt dam and power system is \$3,200,000.



ROOSEVELT DAM SITE, SALT RIVER, ARIZONA.

The plans of the reclamation engineers in Nevada are so broad and comprehensive, involving the storage of the floods of the four principal rivers of that State, that the work has been subdivided. The attention of the Service was given first to the sub-project on the Truckee River, and contracts to construct the main canal from this stream were signed in August, 1903. The work is now practically complete. In August, 1904, contracts were signed for the main lateral systems for utilizing the waters of this canal; and on December 15 proposals were opened for constructing about 150 miles of distributing ditches, which will complete the irrigation system for about 50,000 acres of land. The Secretary of the Interior has set aside the sum of \$3,000,000 for this project.

PROJECTS READY FOR CONSTRUCTION.

COLORADO.—In Colorado the attention of the Service has been concentrated principally upon the Uncompahgre project, which contemplates the irrigation of lands in the Uncompahgre Valley, the waters being diverted from Gunnison River. The two drainages are divided by the Vernal Mesa, which has a general elevation of 8,000 feet. At the point of diversion the Gunnison is in a profound cañon more than a thousand feet below the mesa's summit. By a dam in the Gunnison River the waters of this stream will be diverted into a tunnel 6 miles long, excavated under the Vernal Mesa, and conveyed therein to canals in the Uncompahgre Valley. Contracts have been awarded on this project for the construction of a telephone system, the south canal, and the great Gunnison tunnel, and work is being actively pushed on the former. It is expected that the contractors will begin the tunnel in the very near future, and this work will require more than three years for its construction. The estimated cost of this project is \$2,500,000, and the area reclaimed will be approximately 100,000 acres.

IDAHO.—In September, 1904, contracts were awarded for the diversion dam and a portion of the main canal from Snake River, near Minidoka, Idaho. The contractors are making active preparations for pushing this work throughout the winter months. By this project it is proposed to reclaim from 130,000 to 150,000 acres of desert land belonging to the United States. The natural conditions are unusually favourable for the development of power, and it is proposed to establish pumping plants which will develop 17,500 horse-power during low stages of the river. This power will be utilized for the irrigation of 76,000 acres of land in the Minidoka tract which lies at too high an elevation to be supplied through a gravity system. The estimated cost of the Minidoka project is \$2,600,000.

NEW MEXICO.—The reclamation engineers have located a feasible project in New Mexico in the valley of the Hondo River, about 12 miles southwest from the town of Roswell. The reservoir site was found and surveyed, and authority was given by the Secretary of the Interior to proceed with the project. Contracts were let September 6th for the construction of six miles of canal, several earthen dams, together with headworks, outlet works, sluice gates, etc. It is estimated that this project will cost \$250,000, and will supply water to 12,000 acres.

NEBRASKA AND WYOMING.—Preliminary work this season has developed an attractive project on the North Platte River. This project involves some interesting inter-State features, as the lands to be irrigated are in Wyoming and Nebraska. As a result of the preliminary surveys an excellent reservoir site of large capacity has been located at the beginning of the cañon below the mouth of Sweetwater River. It is proposed to construct here a dam 75 feet in length at the bottom, 250 feet long on top, and 200 feet high. Surveys show that the capacity of the reservoir thus created will be 1,080,000 acre-feet, which it is believed is sufficient to contain all the flood and surplus waters of the North Platte at that point. The estimated cost of this dam is \$1,000,000. To reach the irrigable lands the canal will have a length of 140 miles, making it the longest canal in any of the projects under consideration. The plans call for an expenditure of not less than \$5,000,000 to complete the system. The acreage is not fully determined, but it is believed sufficient land can be included to bring the initial cost within \$25 per acre. Proposals for the construction of the outlet tunnel have been invited, and bids will be opened in Washington January 9th.

NORTH DAKOTA.—In North Dakota careful investigations were made of two proposed pumping projects, one at Bismarck and the other near Fort Buford. Both were decided to be feasible, and the Secretary of the Interior set aside \$550,000 for construction. On the north side of the Missouri River a series of flats extends from the Montana-North Dakota line to about 4 miles east of Williston, North Dakota. Another series of similar flats is located near Bismarck, the combined area of irrigable lands approximating 38,000 acres. These flats are considerably higher than river, and pumping will be necessary to cover them with water. Lignite of fine quality, apparently inexhaustible in quantity, found near by, furnishes fuel at a maximum cost of \$2 per ton. Completion of these projects depends upon the action of the owners of the land under them, who must pledge their property as security for the repayment to the Government of the cost of the irrigation works.

OREGON.—In Oregon the attention of the service has been given principally to the Malheur project in the southeastern part of the State. By this project it is proposed to supply water to 90,000 acres of bench and bottom lands in the valley of the Malheur and Owyhee Rivers. Reservoir sites of ample capacity have been located and mapped, and more than 70 miles of canal lines with topography have been completed. A water users' association, composed of

land owners in the district, has been organized to secure the co-operation of the Government in irrigating lands in private ownership. The detailed plans and estimates will be ready for bids as soon as all the land owners in the valley join this association. The cost of the Malheur project will approximate \$2,600,000.

SOUTH DAKOTA.—Maps, plans, and estimates have been prepared of all structures in connection with the Belle Fourche project in South Dakota, and bids will be advertised for on February 1st, 1905. This project involves the reclamation of land to the north-east of the Black Hills in Butte and Meade counties, by the diversion of waters from the Belle Fourche and Redwater rivers into a natural reservoir six miles from the town of Belle Fourche. From the reservoir the water will be distributed to lands in the valley on both sides of the Belle Fourche River, the water supply being sufficient for the irrigation of approximately 100,000 acres of land. The estimated cost of the Belle Fourche project is \$2,100,000, and three years will probably be required for its completion.

RECONNAISSANCE AND PRELIMINARY SURVEYS.

A large number of parties have been employed during the past year in all of the arid States and Territories on reconnaissance and preliminary surveys. Numerous petitions have been received from all parts of the arid regions, requesting that investigations be made of projects believed to exist in each locality, and much of the reconnaissance work has been undertaken in compliance with these requests. Only the most important of these surveys are noted here.

ARIZONA.—Hydrographers and hydrologists were engaged in several parts of Arizona during the season. Valuable and important data were secured concerning the underground water supply and the areas to which it can be applied to advantage. Part of this investigation was carried on in co-operation with the officials of the Indian Office, who are endeavouring to relieve the distressing conditions of several thousand Indians who have been brought almost to starvation on account of the water famine.

CALIFORNIA.—California, with its vast area and varied topography, has received the earnest consideration of several parties of reclamation engineers during the season. An important branch of the investigation, however, has been carried on in the drainage basin of the Colorado, where the engineering problems have been found most difficult of solution. Although the entire watershed of

this stream is in the United States, a small portion of its lower valley is in Mexico. While it receives no water from the latter country, the Colorado is classed among the international streams, and, under existing treaties, is considered as a navigable river. Diversion of the stream for irrigation is not permissible under existing law if navigation is affected thereby. Last winter Congress passed a law authorizing the Secretary to construct irrigation works to irrigate lands on both sides of the river above Yuma, Arizona. The plans of the engineers have been perfected, and it is estimated that 107,000 acres can be irrigated at a cost of \$35 per acre. As outlined, the project includes an expensive system of levee and irrigation works, together with a diversion dam and long canals.

In California the field investigations in 1904 covered a wide range of territory. Considerable attention was given to the Sacramento Valley, the work here being carried on in co-operation with the State. The field is so large that another season will be required before it can be completed. In the eastern part of the State a study was made of both surface and underground waters in Owens Valley. On the northern boundary of the State the preliminary surveys indicated a feasible project in the basin of Klamath River, which includes irrigable lands in both California and Oregon. The project is an attractive one, as the water supply is ample for a large body of irrigable land in that locality. The engineering features are unique, inasmuch as it is proposed to reclaim a large body of marsh lands, at the same time using the drainage waters for irrigating areas farther down the river. Enormous undeveloped water-powers have been found on Klamath River, which may later be utilized for pumping water to higher levels than those which can be reached by gravity systems.

COLORADO.—The preliminary plans for a project in northwestern Colorado were completed this year, and are ready for the consideration of the consulting engineers. By this project it is proposed to divert the waters of White River for the irrigation of 90,000 acres of land in Routt and Rio Blanco counties. The estimated cost of this project is \$2,000,000.

IDAHO.—In Idaho field parties have been engaged upon preliminary investigations of two projects, one in the southwestern part of the State, called the Payette-Boise, and the other in the eastern part, known as the Dubois project. The former, in the extent of the irrigated area and productivity of the soil, ranks among the

most important projects now being considered by the Service. The engineering features are comparatively simple, notwithstanding the plans contemplate using the waters of one stream in the valley of the other. The engineers propose to construct a diversion dam in the Payette River and, by means of a canal several miles in length and a short tunnel passing through the narrowest point in the divide which separates the two rivers, turn the waters into the Boise valley. The majority of the land owners in the valley have signified their approval of the enterprise. The acreage involved is nearly 300,000.

The Dubois project, located in the eastern part of the State, is one of considerable magnitude, embracing approximately 200,000 acres of Government land. The reconnaissance work on this project covered 1,570 miles, the surveys of canal lines aggregate 369 miles, and surveys of reservoirs 116 miles. Another season will be required to complete the preliminary work.

MONTANA.—Montana has proved a most inviting field for the prosecution of reclamation investigations during the past year, and prospects are encouraging for the development of several large projects which will make productive and valuable many thousand acres of land now arid and worthless. Attention in 1904 has been given chiefly to the Milk River project, in the northern part of the State. The progress of the work here has been considerably delayed by questions of an international character which have arisen, and which ultimately must be considered by the State Departments of both Governments. The project contains some unusual features, due to the fact that the Milk River, which rises in Montana, flows for many miles through Canadian territory before it turns southward to join the Missouri in Montana. At several points along its channel in Canada its waters are diverted for irrigation, and complications over prior water rights are certain to arise in the event that our Government should attempt to control the waters of this stream. The first plan considered by the engineers was to impound the waters of St. Marys River in the lakes of the same name in northern Montana and, by a canal, divert them into Milk River, which heads near the lakes. St. Marys River has a high mountain drainage, and is a constant stream; but, unfortunately, it flows north into Canada, and never comes back. To use the flood-waters of this stream to best advantage they must be permitted to run down Milk River for several hundred miles, partly in Canada, before they can be diverted

to irrigable lands in Montana. Unless satisfactory arrangements can be made with Canada for an equable division of the water, Montana irrigators will be at the mercy of the Canadian appropriators, who, of course, have first use of the water. For a portion of the summer the engineers have been working on plans to store the floods of Milk River in natural basins, and detailed estimates of the cost and of the irrigable area will soon be prepared for submission to the Chief Engineer.

While another year will be required to work out all the details of the Sun River project in this State, the preliminary surveys made this year indicate that a large project, embracing 300,000 acres, exists in this drainage basin, for which the water supply is ample.

By authority of Congress the Reclamation Service this spring made a preliminary reconnaissance and survey of the ceded lands in the Crow Indian reservation. The report of the engineers is favourable, and it is believed that the final surveys will develop a project which will reclaim 200,000 acres of fertile land in this section.

On the Yellowstone the surveys have developed a feasible project near Glendive, where a canal 70 miles in length will cover 60,000 acres in Montana and North Dakota. The estimated cost of this project is \$1,800,000.

NEW MEXICO.—Preliminary investigations in New Mexico this season covered a large portion of the territory and developed feasible projects on three streams. Of these the most important is undoubtedly that on the Rio Grande, known as the Engle project. Presenting as it does a satisfactory solution of the serious international controversy over water rights on this stream, which for a quarter of a century has been at fever heat in the lower valley, future history may decide that Peacemaker is a more appropriate name. The Engle project contemplates the storage of 2,000,000 acre-feet, or the entire normal and flood discharges of the Rio Grande, in a deep and narrow reservoir so large that 82 years of the silt-laden floods of this torrential and turbid stream will not destroy more than 60 per cent. of its efficiency. An area of 180,000 acres of land likened unto the famous Nile valley in fertility and productivity will receive an abundant and constant water supply, and a region which is now rapidly returning to its original state, that of a desert, through lack of water, will furnish homes for 90,000 happy and contented people. The entire cost of the reservoir, diversion dams, and canals is estimated at \$7,200,000, or

\$40 per acre. During the recent Irrigation Congress at El Paso the Chief Engineer of the Reclamation Service fully explained all the plans of the Engle Project, and the delegates from Mexico, Texas, and New Mexico voiced their approval without a single dissenting vote. The Engle project renders the international dam unnecessary. Its construction will settle for all time the deplorable and unhappy conditions which have so long existed in the valley. It will inaugurate an era of good feeling, of rapid and substantial development, in a section where irrigation is older than our written history.

The Urton project on Pecos River will divert the waters of this stream by means of a dam and a canal 35 miles long, the waters being stored in a large natural basin or reservoir provided with an outlet tunnel and distributing canals. The cost of the work will approximate \$1,000,000, and the acreage supplied will be 60,000.

The Las Vegas project contemplates conducting water from Gallinas and Sapello Rivers to a point about five miles north of Las Vegas into a natural reservoir created by constructing a dam across a narrow arroyo. Investigations of the water supply will be continued through the year. A topographic map of the reservoir site and irrigable lands has been made.

OKLAHOMA.—Numerous investigations have been made in Oklahoma for irrigation possibilities, special attention being given to a study of water storage propositions in the country east of the Wichita Mountains and in Beaver County. Very careful investigation has also been made of the underground water resources. The work in this territory has not progressed to a point where a feasible project has yet been decided upon, and the surveys will be continued during 1905.

UTAH.—Two projects have occupied the time and attention of the engineers in Utah during the season, one at Utah Lake and the other at Bear Lake. Both projects are full of complications owing to the heavy diversion of the waters of the streams entering into and flowing from these lakes, and at least another year will be required to complete the preliminary investigations.

WASHINGTON.—The principal reclamation project in Washington, known as the "Big Bend" project, is of such magnitude that the present state of the irrigation fund does not at this time warrant its inauguration. In its entirety the Big Bend project involves an expenditure in excess of the whole reclamation fund. Nearly 5,000,000 acres of fertile lands are included within its boundaries,

and the storage of the waters in numerous lakes and rivers is contemplated.

The work for the past season has been concentrated chiefly upon the Palouse project in the southeastern part of the State, preliminary surveys having shown its feasibility to the extent of irrigating at least 100,000 acres. Several parties have been engaged upon surveys of canal lines, irrigable lands, and reservoir and dam sites, and these data will be ready for consideration during the winter. The estimated cost of the system is \$1,395,035.

WYOMING.—In Wyoming a rapid reconnaissance was made for a canal in that portion of the Wind River or Shoshone Indian reservation which is soon to be opened to settlement. The engineers' reports indicate that one or more feasible projects might be constructed there should Congress so order. The lands are exceedingly fertile, the water supply apparently ample, and the engineering features simple and inexpensive.

During a portion of the season work has been pushed vigorously on the Shoshone project, which contemplates the utilization of a portion of the surplus water of Shoshone River for the reclamation of land in the northern part of Big Horn County, Wyoming. A reservoir site has been found on this stream just below the junction of its North and South Forks, where it enters a deep cañon. The plan for a dam and headworks has been passed upon by a board of consulting engineers, and the sum of \$2,250,000 was set aside by the Secretary of the Interior in February, 1904. The progress of the work has been delayed owing to unforeseen difficulties which were encountered in boring for bed rock at the dam site. Preliminary to the boring at the main dam work was begun on the wagon road into the cañon for the transportation of materials and telephone lines from the railroad to the dam site. The irrigable area to be covered by this project is approximately 103,000 acres.

POWER AND PUMPING INVESTIGATIONS.

The electrical experts of the Service during the past season have made a study of power development and pumping features, the utilization of power in pumping water to higher levels being essential to the success of several of the projects. Some of these projects depend entirely upon pumping water for irrigation. On others it is proposed to utilize natural power sites wherever they can be found in the vicinity, and develop power to cover lands above the lines of gravity systems.

Similar studies have been made also in conjunction with the exceedingly important investigations of underground water resources of several important drainage basins, upon which a number of hydrologists have been employed in the West. Plans have been formulated for developing and utilizing power in construction work, thereby effecting a considerable saving in labour and time and in the first cost of permanent structures.

VAN DER GRINTEN'S CIRCULAR PROJECTION.

BY

G. W. LITTLEHALES.

Owing to the geometrical impossibility of developing a spherical or spheroidal surface in a plane, geographers have adopted various artifices, called projections, for representing, on a reduced scale and on a plane surface, the relative positions of points, lines, or objects on the earth's surface; and, since such positions are usually defined by spherical co-ordinates, the primary object of these artifices is the delineation of these circles of reference so that any point, line, or object intended for representation may be laid down according to its known co-ordinates. These so-called projections fall in three classes or subdivisions. The first comprises the true or perspective projections, like the orthographic and stereographic, in which the framework of parallels of latitude and meridians of longitude is represented as a spectator would see them on a plane surface placed in a definite relative position back of the globe upon and through which he is looking.

The second class is made up of those projections like the Mercator and the conic, in which the lines of spherical co-ordinates are first projected upon a circumscribing cylindrical or conical surface, which is afterwards conceived to be developed upon a plane surface by being cut open along an element of the cylinder or cone and then spread out flat.

The third class includes those projections which are neither formed by projection nor by development, but which are conventional constructions based upon geometrical laws, either assumed or fixed, and not representing the earth in such a way that it could be seen in that form by a spectator in any position whatsoever. Lambert's projection and Mollweide's or Babinet's homolographic